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From **Miyoko Sakashita <miyoko@biologicaldiversity.org>**

To Stephen Johnson/DC/USEPA/US@EPA

cc

Subject Petition Under CWA Sec. 304 to Strengthen pH Criteria to Address Ocean Acidification

Message Body

Dear Administrator Stephen Johnson,

Please find the attached formal petition under Clean Water Act section 304 to strengthen pH water quality criteria and publish guidance to address ocean acidification. This petition is also being sent via certified mail with a compact disc containing the supporting documents.

Sincerely,
Miyoko Sakashita

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PETITION FOR REVISED pH WATER QUALITY CRITERIA UNDER SECTION 304 OF THE CLEAN WATER ACT, 33 U.S.C. § 1314, TO ADDRESS OCEAN ACIDIFICATION

BEFORE THE ENVIRONMENTAL PROTECTION AGENCY

Center for Biological Diversity

Executive Summary

The Center for Biological Diversity formally requests that pursuant to section 304 of the Clean Water Act the United States Environmental Protection Agency (EPA) publish revised water quality criteria and information taking into account new scientific information about ocean acidification. This petition marks the first step toward a national approach to preventing carbon dioxide pollution from degrading the water quality of our oceans.

Carbon dioxide is the most prevalent greenhouse gas, and it not only contributes to global warming but also causes ocean acidification. The ocean absorbs carbon dioxide, which reacts with seawater to make it more acidic—thus altering the chemical composition of the ocean. Approximately half of the carbon dioxide emitted into the atmosphere from human activities over the past 200 years has been absorbed by the oceans.

Carbon dioxide pollution has already lowered average ocean pH by 0.11 units, with a pH change of 0.5 units projected by the end of the century under current emission trajectories. These changes are likely to have devastating impacts on the entire ocean ecosystem. The primary known impact of acidification is impairment of calcification, the process whereby corals, crabs, abalone, oysters, sea urchins, and other animals make shells and skeletons. Many species of phytoplankton and zooplankton, which form the basis of the marine food web, are also particularly vulnerable to ocean acidification. Laboratory studies have shown that at carbon dioxide concentrations likely to occur in the ocean in the next few decades, the shells of many marine species deform or dissolve. Scientists predict that the majority of coral reefs will turn to rubble before the end of the century. Absent significant reductions in carbon dioxide emissions, ocean acidification will accelerate, likely ultimately leading to the collapse of oceanic food webs and catastrophic impacts on the global environment.

The Clean Water Act is the nation's strongest law protecting water quality. Because ocean acidification is changing seawater chemistry and degrading water quality, EPA needs to address this threat before it harms marine life and resources. Among the tools that the Clean Water Act uses to control water pollution are the national water quality criteria. States use the criteria in adopting water quality standards and developing pollution controls. EPA already lists pH as a "pollutant" in its regulations and it developed pH water quality criteria in 1976.

New information on ocean acidification, however, has rendered the existing water quality criteria for pH outdated and inadequate. Under the Clean Water Act, EPA has a duty to periodically update water quality criteria to reflect the latest scientific knowledge. This Petition presents scientific information on ocean acidification and requests that EPA promptly revise the water quality criteria to take new information about ocean acidification into account. Specifically, the Petition requests that EPA (1) revise pH criteria to reflect new ocean acidification science and adopt a criterion prohibiting any

measurable change in pH of marine waters, and (2) publish information concerning ocean acidification to guide states in monitoring and preventing harmful ocean acidification.

Administrator of the Environmental Protection Agency

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Right to Petition

The right of an interested party to petition a federal agency is a freedom guaranteed by the first amendment: "Congress shall make no law ... abridging the ... right of people ... to petition the Government for redress of grievances" (U.S. Const., amend I.).[1]

Under the Administrative Procedures Act (APA), all citizens have the right to petition for the "issuance, amendment, or repeal" of an agency rule (5 USC § 553(e)). A "rule" is the "whole or a part of an agency statement of general or particular applicability and future effect designed to implement, interpret, or prescribe law or policy" (5 USC § 551(4)). In the present case, the EPA issued a final rule containing criteria for pH and other conventional pollutants (51 Fed. Reg. 43665 (1986)). Thus, the petitioners have the right to petition for revision of this rule. EPA is required to respond to this petition: "Prompt notice shall be given of the denial in whole or in part of a written application, petition, or other request of an interested person made in connection with any agency proceeding" (5 U.S.C. § 555(e)).

The petitioned action is for a non-discretionary action under the Clean Water Act and therefore the agency is required to respond and the action is enforceable. This petition is enforceable under the citizen suit provision of the Clean Water Act (33 U.S.C. § 1365). The federal district courts of the United States have jurisdiction over a claim that the Administrator of the EPA has failed to perform a non-discretionary duty (33 U.S.C. § 1365(a)(2)). The subject of this petition, revision of guidelines under section 304, is a non-discretionary duty because the current guidelines do not reflect the latest scientific knowledge and fail to protect marine water quality, as required by the Clean Water Act.

[1] See also *United Mine Workers v. Illinois State Bar Ass'n*, 389 U.S. 217, 222 (1967) (right to petition for redress of grievances is among most precious of liberties without which the government could erode rights).

Further, the APA provides for judicial review of a final agency action (5 U.S.C. § 704). The scope of review by the courts is determined by section 706 of the APA (5 U.S.C. § 706). The APA also permits courts to compel agency action unlawfully withheld or unreasonably delayed (*Id.*).

Petitioner

The Center for Biological Diversity is a nonprofit environmental organization dedicated to the protection of imperiled species and their habitats through science, education, policy, and environmental law. The Center's Oceans Program aims to protect marine life and ocean ecosystems in United States and international waters. The Center has over 35,000 members. The Center submits this petition on its own behalf and on behalf of its members and staff with an interest in protecting the ocean environment.

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Respectfully submitted,

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I. Introduction

Our national oceans are in grave danger due to ocean acidification. Ocean acidification refers to the reduction in ocean pH caused by increased carbon dioxide concentration in ocean waters. The increase in carbon dioxide is a direct result of human activities including fossil fuel burning. Ocean pH has already decreased by over 0.1 pH units since the Industrial Revolution, which corresponds to a 30 percent increase in acidity. This decrease in pH has already had deleterious effects on the ocean ecosystem and calcareous organisms in particular. A further decrease will have dramatic and irreversible consequences.

The Center for Biological Diversity formally requests that the United States Environmental Protection Agency (EPA) initiate a rulemaking pursuant to the Clean Water Act, 33 U.S.C. § 1314(a), to address threats posed by ocean acidification. This Petition for rulemaking specifically requests that the EPA:

(1) Revise national water quality criteria for pH to reflect the latest scientific knowledge about ocean acidification, and pursuant to section 304(a)(1) should adopt a criterion stating:

- **For marine waters, pH should not deviate measurably from naturally occurring pH levels as a result of absorption of anthropogenic carbon dioxide pollution.**

(2) Publish information pursuant to section 304(a)(2) to provide guidance on ocean acidification, including:

- **the factors necessary to prevent deleterious pH changes in seawater chemistry due to anthropogenic carbon dioxide emissions;**
- **the factors necessary to prevent adverse impacts of ocean acidification on fish, shellfish, and wildlife; and**
- **the recommended methods for measuring pH and monitoring change over time.**

The dire threat posed by ocean acidification has been extensively documented by the scientific literature over the last several years. There is now an overwhelming consensus in the scientific community that "business as usual" trends in anthropogenic carbon dioxide emissions will wreak havoc with the ocean ecosystem. For example, scientists predict that ocean acidification coupled with global warming will kill nearly all of the coral reefs before the end of the century, threatening reef dependent animals as well (Hoegh-Guldberg et al. 2007).

Under current trajectories, ocean acidification will cause seawater to exceed EPA pH water quality criteria by mid-century, as summarized in a recent article by 25 of the leading scientists studying ocean acidification (Caldiera 2007). They note that ample scientific research demonstrates that pH changes of the magnitude currently allowed by

EPA's water quality criteria will pose serious risks to marine life (*Id.*). One of the authors commented, "we need to start thinking about carbon dioxide as a pollutant in the ocean" (Carnegie Institution for Science 2007).

As the nation's premier mechanism for protecting water quality, the Clean Water Act was designed to address water pollution; including water degradation from pH changes. Under the Clean Water Act, the EPA is required to promulgate the rules necessary "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. § 1251(a)). One of the methods for addressing national water quality concerns is through national water quality criteria created pursuant to section 304 of the Clean Water Act (33 U.S.C. § 1314(a)(1)).

The Clean Water Act requires EPA to periodically update its rules to reflect the latest scientific knowledge. Section 304 mandates that the EPA promulgate and revise national water quality criteria "from time to time" to reflect the "latest scientific knowledge." However, EPA has not revised the pH criteria since they were originally promulgated in 1976. New information about ocean acidification warrants revision of the pH criteria. These national water quality criteria are the basis for state water quality standards and pollution controls; thus, it is crucial that they reflect the latest science.

The problem of ocean acidification is the result of nation-wide activity. The solution requires the concerted effort of all the states. Revised national pH criteria and information on ocean acidification are critical to ensure that all of the states act together to reduce carbon dioxide and the resulting ocean acidification.

The Clean Water Act mandates that the EPA protect the nation's water quality, and EPA needs to act promptly to address the threats of ocean acidification. Therefore, it is appropriate for EPA to promulgate the rules requested in this petition.

II. Clean Water Act Background

The objective of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. § 1251(a)). According to the Supreme Court "[T]he Act does not stop at controlling the 'addition' of pollutants,' but deals with 'pollution' generally...which Congress defined to mean 'the manmade or man-induced alteration of the chemical, physical, biological, and radiological integrity of water'" (*S.D. Warren v. Maine Bd. Of Envt'l Protection,* 126 S.Ct. 1843, 1852-53 (2006)). The national goal of the Clean Water Act is to guarantee "water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation" (33 U.S.C. § 1251(a)(2)).

Toward these goals of eliminating water pollution and maintaining the water quality of the nation's waters, the Clean Water Act provides a variety of tools to control water pollution from all sources. The Clean Water Act requires that states adopt water quality standards (33 U.S.C. § 1313). Water quality standards include: designated uses, water quality criteria sufficient to protect the designated uses, and an antidegradation policy (40 C.F.R. § 131.6). States are required from time to time (and at least every three years) review and, if necessary, revise water quality standards (33 U.S.C. § 1313(c)).

State water quality standards are the foundation of the Clean Water Act and are at the heart of each strategy of pollution control under the Act. For example, section 402 requires polluters to obtain permits and adhere to effluent limitations and technology controls necessary to meet water quality standards (33 U.S.C. §§ 1342, 1311). Section 303 requires states to identify impaired waterbodies—those failing to meet water quality standards—and establish limits on pollutants causing the impairment (33 U.S.C. § 1313(d)). Moreover, section 401 requires applicants for any federal permit or license to obtain state certification that the permitted activity will comply with state water quality standards (33 U.S.C. § 1341).

Although, implementation of the Clean Water Act is generally delegated to the states, Congress charged EPA with the national implementation of the Clean Water Act. To accomplish this task, the EPA has broad authority to execute the mandates of the Clean Water Act: "The Administrator is authorized to prescribe such regulations as are necessary to carry out his functions under this chapter" (33 U.S.C. § 1361(a)). Relevant here, the Clean Water Act requires the EPA to establish national water quality criteria, 33 U.S.C. § 1313(a)(1), and publish information on the protection of water quality, 33 U.S.C. § 1313(a)(2), to guide states in their adoption and periodic review of water quality standards. Water quality criteria and information, and revisions thereof, are required to be issued to the states and published in the Federal Register and otherwise be made available to the public (33 U.S.C. § 1313(a)(3)).

a. National Water Quality Criteria

Under section 304, Congress mandated that the EPA "shall" develop and publish and "from time to time thereafter revise" water quality criteria "accurately reflecting the latest scientific knowledge:"

> (A) on the kind and extent of all identifiable effects on health and welfare including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, esthetics, and recreation which may be expected from the presence of pollutants in any body of water, including ground water;
> (B) on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes; and
> (C) on the effects of pollutants on biological community diversity, productivity, and stability, including information on the factors affecting rates of eutrophication and rates of organic and inorganic sedimentation for varying types of receiving waters

(33 U.S.C. § 1314(a)(1)). "[W]hen a statute uses the word 'shall,' Congress has imposed a mandatory duty upon the subject of the command" (*Forest Guardians v. Babbitt*, 174 F.3d 1178, 1187 (10th Cir. 1998)). The duty to review and consider required factors, such

as the latest scientific knowledge, is a non-discretionary duty (*See Our Children's Earth v. EPA*, 506 F.3d 781 (9th Cir. 2007)(examining a parallel provision of the Clean Water Act)).

Pursuant to section 304's mandate, EPA issued the "Blue Book" of Water Quality Criteria in 1973. In 1976, EPA published the "Red Book" which contained the water quality criteria for pH that is still used today. It stated:

> For open ocean waters where the depth is substantially greater than the euphotic zone, the pH should not be changed more than 0.2 units outside the naturally occurring variation or in any case outside the range of 6.5 to 8.5

(Quality Criteria for Water 1976: 342-43). In 1986, the "Gold Book" summarized water quality criteria in effect with no change to the pH criteria for oceans (Quality Criteria for Water 1986). Since then EPA has periodically updated water quality criteria under section 304(a)(1) to accurately reflect the latest scientific information, however, the pH criterion above remains in effect today.

b. Water Quality Protection Information

Section 304(a)(2) requires that EPA "shall" develop and publish "and from time to time thereafter revise" information on four topics necessary to protection of water quality:

> (A) on the factors necessary to restore and maintain the chemical, physical, and biological integrity of all navigable waters, ground waters, waters of the contiguous zone, and oceans;
> (B) on the factors necessary for the protection and propagation of shellfish, fish, and wildlife for classes and categories of receiving waters to allow recreational activities in and on the water; and
> (C) on the measurement and classification of water quality; and
> (D) for the purpose of section 1313 of this title, on the identification of pollutants suitable for maximum daily load measurement correlated with the achievement of water quality objectives.

(33 U.S.C. § 1314(a)(2)). The publication of this information is critical because it provides states with the necessary information to evaluate the needs of the waters in their jurisdiction, which may require modification of state water quality standards or pollution control requirements.

c. The Role of Criteria and Information in Protecting Water Quality

The national water quality criteria and information required by section 304 are significant because they establish a baseline for nationwide implementation of the Clean Water Act. Guided by EPA's criteria and information, states must either adopt the national recommended water quality criteria in their water quality standards or provide a science-based explanation for their alternate criteria:

> In establishing criteria, States should:
> (1) Establish numerical values based on:
> (i) 304(a) Guidance; or
> (ii) 304(a) Guidance modified to reflect site-specific conditions; or
> (iii) Other scientifically defensible methods;
> (2) Establish narrative criteria or criteria based upon biomonitoring methods where numerical criteria cannot be established or to supplement numerical criteria.

(40 C.F.R. § 131.11(b)). EPA oversees state water quality standards and must either approve the states' standards or promulgate standards for that state guided by the national water quality criteria (See, e.g., 33 U.S.C. § 1313(b)).

In turn, the state water quality standards impact virtually all aspects of pollution control. For point sources of pollution, states use the standards to set effluent limits and technology standards for water pollution. The Clean Water Act requires compliance with such measures by requiring a permit for the discharge of any pollutant from a point source (33 U.S.C. §§ 1311, 1342). For control of both point source and non-point source pollution, water quality standards are also determinative. The Clean Water Act's section 303(d) requires each state to "identify those waters within its boundaries for which the effluent limitations ... are not stringent enough to implement any water quality standard applicable to such waters" (33 U.S.C. § 1313(d)(1)(a)). A water body failing to meet any numeric criteria, narrative criteria, waterbody uses, or antidegradation requirements shall be identified (40 C.F.R. § 130.7(b)(3)), states "shall" establish a total maximum daily load (TMDL) for pollutants "at a level necessary to implement the applicable water quality standards" (33 U.S.C. § 1313(d)(1)(C)). Therefore, water quality standards provide a mechanism for states to regulate all sources of pollution that are degrading water quality.

It is obvious that the EPA's 304(a) criteria are at the very heart of protection of water quality across the nation. The result is that, effectively, the national water quality criteria set the lower limit for water quality standards. When the federal criteria are outdated, water quality throughout the nation suffers.

III. New Information on Ocean Acidification

The scientific community's comprehension of the dangers of ocean acidification has developed relatively recently. This new knowledge has revealed that immediate action is essential if the irreversible loss of marine ecosystems is to be avoided (Carnegie Institution for Science 2007, Hoegh-Guldberg 2007). Such a major change in scientific information requires amendment of pH criteria under section 304(a) of the Clean Water Act.

Carbon dioxide absorbed from the atmosphere is polluting ocean waters. Carbon dioxide is readily exchanged between the atmosphere and the sea surface. The increase in carbon dioxide is a direct result of human activity—fossil fuel burning. Due to the fact that the ocean has a carbonate buffer system, an increase in aqueous carbon dioxide reduces the concentration of carbonate while increasing the concentration of bicarbonate. The result is a decrease in ocean pH.

The reduction in free carbonate ions harms organisms that form calcium carbonate shells. There is a profound impact on the entire marine ecosystem due to the fact that many calcifying plankton, the basis of the food web, are severely affected by ocean acidification. Furthermore, organisms such as fish also experience direct effects from increased ocean carbon dioxide, which include metabolic, immune, and reproductive dysfunction.

The scientific evidence for the destructive effects of ocean acidification is practically unanimous. A recent comment letter signed by the top 25 marine scientists who study ocean acidification emphasized that the decrease in pH due to un-checked carbon dioxide emissions will be devastating and irreversible on human time scales (Caldiera 2007). The authors predict that without immediate carbon dioxide emissions reductions, pH will decrease by more than 0.2 units—the current EPA guideline for pH—by mid-century.

Ocean acidification has also been recognized by advisory bodies. For instance, the United States Commission on Ocean Policy (USCOP) characterizes climate change as "among the most pressing scientific questions facing our nation and the planet" (Ocean Blueprint 2004). Furthermore, the USCOP report states that ocean acidification is impairing some organisms and has "potentially profound impacts on marine production and biodiversity" (Ocean Blueprint 2004). The resulting recommendation is that scientific information be used to modify management strategies. Likewise, the Pew Commission discussed the myriad effects of climate change on marine life, including changes in ocean chemistry. The report stated that the Commission "feels strongly" that the U.S. must reduce its emission of greenhouse gases to limit injury to the marine environment (Living Oceans 2003).

Because ocean acidification is driven by basic chemical reactions, it is relatively easy to predict future changes in ocean pH. According to "business as usual" scenarios for future carbon greenhouse gas emissions, ocean pH may drop by another 0.4 units by the end of the century. This would result in massive, irreparable losses in the ocean ecosystem.

The oceans have already taken up about 50% of the carbon dioxide that humans have produced since the industrial revolution, and this has lowered the average ocean pH by 0.11 units (Sabine 2004). Although this number sounds small, it represents a significant change in acidity. The ocean takes up about 22 million tons of carbon dioxide each day (Feely 2006). While preindustrial levels of atmospheric carbon dioxide hovered around 280 ppm (Orr 2005), they have now increased to 380 ppm; if current trends continue they will increase another 50% by 2030 (Turley 2006). These rising carbon dioxide levels are irreversible on human timescales (Kleypas 2006). Over time, the ocean will absorb up to 90% of anthropogenic carbon dioxide released into the atmosphere (Kleypas 2006).

Present day levels of atmospheric carbon dioxide are the higher than they have been for at least 420,000 years, and likely for over 20 million years. (Royal Society 2005). Historically, carbon dioxide levels increased relatively slowly, allowing marine ecosystems time to adapt. In stark contrast, the current rate of rise in atmospheric carbon dioxide is an unprecedented 100 times faster than any other rise in the last hundreds of thousands of years (Ruttimann 2006). Unlike future climate change, the pH change in response increased atmospheric carbon dioxide is relatively easy to predict because it involves basic chemical reactions and is unlikely to be affected by global temperature change (McNeil 2006). Thus, there is a strong consensus in the field that the oceans will undergo extensive acidification as the atmospheric carbon dioxide concentration rises.

Studies have established that anthropogenic carbon dioxide is the direct cause of the decrease in ocean pH. For instance, a tracer technique can be used to separate naturally occurring and dissolved carbon from that due to human activity (Gruber 1996). Oceans absorb carbon dioxide more slowly than humans are currently releasing it. Current levels of anthropogenic carbon dioxide have virtually guaranteed that ocean pH will continue to decrease in the foreseeable future. Anthropogenic carbon dioxide emissions will result in a decrease in oceanic pH of 0.4 units by 2100 according to a model based on IPCC scenarios (Caldeira 2003). If action is not taken until those changes occur, it will be too late to effectively mitigate the damage.

Although much of the air-sea exchange of carbon dioxide occurs in open water, a recent report underscored the potentially massive impacts on coastal waters (Kleypas 2006). Shallow waters are affected before deeper waters. These areas constitute only 7% of the ocean's surface and yet support up to 30% of marine production. A model based on "business as usual" carbon dioxide emissions scenarios predicts that calcification could decrease by 40% by 2100, and that calcium carbonate would dissolve faster than it could be produced by 2150 (Andersson 2006).

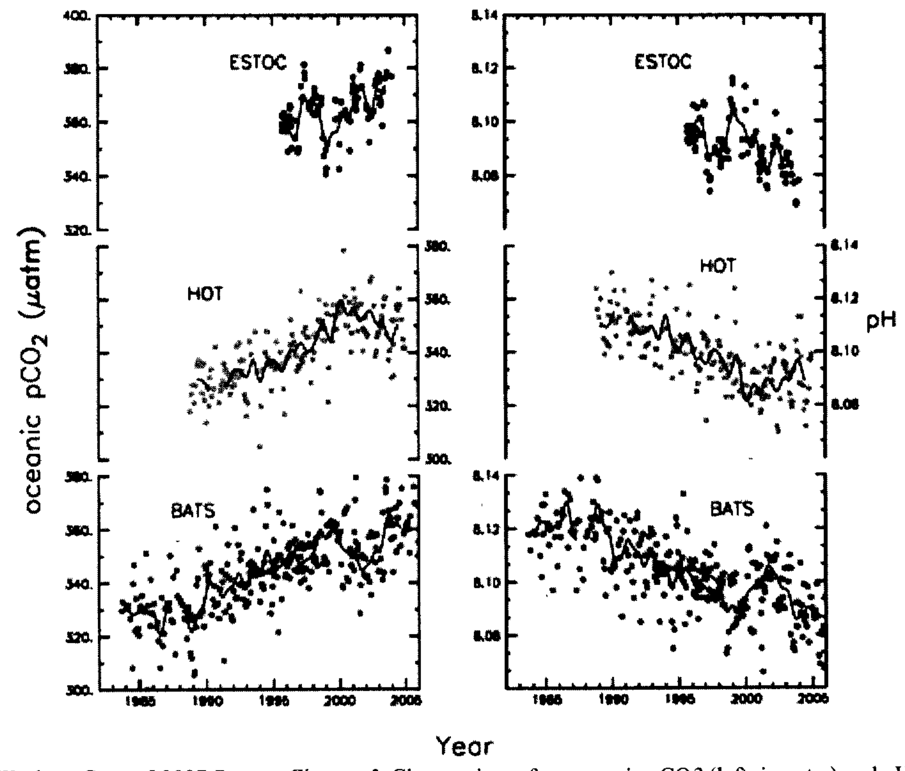
a. Carbon Dioxide Is Changing Seawater Chemistry

The carbonate system is the ocean's buffer. The three dominant forms of carbon dioxide in the ocean are: aqueous carbon dioxide, bicarbonate, and carbonate. True carbonic acid is also present in small quantities. The ocean pH increases as the concentration of carbonate increases and decreases, or becomes more acidic, as the concentrations of bicarbonate and carbon dioxide/carbonic acid increase.

Carbon dioxide that is absorbed by seawater reacts to form carbonic acid, which dissociates to form bicarbonate and releases hydrogen ions. This reaction reduces the amount of carbonate ions and decreases pH. Carbonate is an important constituent of seawater because many organisms form their shells and skeletons by complexing calcium and carbonate. Calcium carbonate is present in the ocean in two common forms, calcite and aragonite. The "saturation horizon" for aragonite and calcite has already shifted toward the surface by 50 to 200 m. This means that calcareous organisms can not survive at the same depths they once could. The depth of water in which they can survive will continue to become shallower in the coming decades (Feely 2004).

The ocean acidification that has already occurred, a decline of 0.11 pH, represents a 30% increase in the concentration of hydrogen ions (Royal Society 2005), and a decrease in the carbonate concentration of 10% (Orr 2005). At present, the effects are greatest in surface waters (< 1000 m) where carbon dioxide exchange occurs with the air, but the decline in aragonite and calcite saturation will extend throughout the water column in some areas by 2100 (Orr 2005). This is important because calcifying organisms form their shells from calcium carbonate, and cannot do so when carbonate is not available to complex with calcium. The loss of these organisms has catastrophic implications for the entire food web.

The decreasing trend in pH has been well documented, as shown by the time-series measurements of pH at various ocean locations from approximately 1983 to 2006. Each location experienced a decrease in pH, and an associated rise in partial pressure of carbon dioxide.



From *IPCC Working Group I 2007 Report, Chapter 5*: Changes in surface oceanic pCO*2* (left; in µatm) and pH (right) from three time series stations: Blue: European Station for Time-series in the Ocean (ESTOC, 29°N, 15°W; Gonzalez-Dávila et al., 2003); green: Hawaii Ocean Time-Series (HOT, 23°N, 158°W; Dore et al., 2003); red: Bermuda Atlantic Time-series Study (BATS, 31/32°N, 64°W; Bates et al., 2002; Gruber et al., 2002). Values of pCO*2* and pH were calculated from DIC and alkalinity at HOT and BATS; pH was directly measured at ESTOC and pCO*2* was calculated from pH and alkalinity. The mean seasonal cycle was removed from all data. The thick black line is smoothed and does not contain variability less than 0.5 years period.

b. Carbon Dioxide Is Harming the Aquatic Ecosystem

Scientists agree that carbon dioxide pollution is causing ocean acidification with adverse impacts on many marine organisms. Available evidence suggests that the consequences of anthropogenic carbon dioxide accumulation have already begun in surface waters (Pörtner 2005). The leading ocean acidification scientists warn that 0.2 pH change—the current EPA water quality criteria for pH—will have adverse impacts on marine life (Caldeira et al. 2007).

One of the most alarming effects of ocean acidification is the impact on the availability of carbonate for calcifying organisms such as mollusks, crustaceans, echinoderms, corals, calcareous algae, foraminifera and some phytoplankton. Nearly all marine species that build shells or skeletons from calcium carbonate that have been studied have shown deterioration when exposed to increasing carbon dioxide levels in seawater (Feely 2006). Estimates suggest that calcification rates will decrease up to 50% by the end of the century (Ruttimann 2006). Snails, sea urchins, starfish, lobster, crabs, oysters, clams, mussels, and scallops all build shells that are vulnerable to ocean acidification. Other marine species may experience physiological effects from acidification including lowered immune response, metabolic decline, and reproductive and respiratory problems (Feely 2006).

1. Ocean Acidification Threatens Calcifying Plankton

Plankton, which play a fundamental role in the marine ecosystem, are threatened by ocean acidification. Carbon dioxide uptake by the ocean causes impaired growth and development for calcifying plankton, and acidification dissolves the protective armor of some plankton. Coccolithophorids, pteropods, and foraminifera are the dominant calcifying planktonic organisms and provide an essential role in marine production. Recent discoveries indicate that plankton in the Southern Ocean have already been adversely affected by ocean acidification (Syndey Morning Herald September 12, 2007).[2]

Coccolithophorids are one of the most important calcite producers and studies show that carbon dioxide in seawater reduces calcification of coccolithophorids (Reibesell 2000). Coccolithophorids are one-celled marine plants in the upper layers of the ocean that bloom in large numbers like many phytoplankton. Phytoplankton, such as coccolithophorids, contribute much of the organic material entering the marine food chain and are responsible for about 50% of the earth's primary production (Royal Society 2005). Coccolithophorids have calcium carbonate structures surrounding them called coccoliths. Studies of coccolithophorids showed that carbon dioxide related changes to seawater caused reduced calcification, malformed coccoliths, and incomplete

[2] http://www.smh.com.au/news/environment/ocean-time-bomb/2007/09/11/1189276723526.html ?page =fullpage#contentSwap1

coccospheres (Riebesell 2000). These phytoplankton not only provide food for other marine organisms but they also influence the global environment by reflecting light from the ocean.

Another example of plankton at risk from ocean acidification are pteropods. Pteropods form their shells from aragonite. Experiments show that the shells of pteropods dissolve as seawater becomes undersaturated with aragonite (Orr 2005). If carbon dioxide pollution continues unabated then large areas of the ocean, especially at higher latitudes, will become undersaturated with aragonite by 2050 (Orr 2005). Krill, whales, salmon, and other fish eat pteropods, and they contribute significantly to marine production. Ocean acidification impedes the calcification of pteropods and even dissolves their protective shells. Not only are pteropods at risk, but also the many organisms that depend on them for food.

Foraminifera, also an important planktonic calcifier, experiences reduced shell mass when exposed to elevated carbon dioxide (Kleypas 2006). There is a strong reduction in foraminifera calcification that corresponds to pH decreases (Royal Society 2005).

2. Large Calcifying Organisms Exhibit Reduced Calcification Due to Ocean Acidification

Larger calcifying animals such as corals, crustaceans, echinoderms, and mollusks are also threatened by ocean acidification. These important members of marine ecosystems are vulnerable to ocean acidification because, like calcifying plankton, they are experiencing reduced calcification and erosion of their protective shells.

Experiments revealed that moderate increases in atmospheric carbon dioxide had significant effects on the survival and growth of sea urchins and snails (Shirayama 2005). These adverse effects on echinoderms and gastropods are alarming because they mimicked long-term exposure to carbon dioxide levels that are likely to be reached within decades (Shirayama 2005). Echinoderms are especially sensitive to ocean acidification because lower pH inhibits the formation of their skeletons which depend on highly soluble calcite precursors (Royal Society 2005, Shirayama 2004). At a pH change of 0.3 units, echinoderms are significantly impacted (Shirayama 2004). Crustacea also are especially vulnerable to sea chemistry changes during molting (Royal Society 2005).

Juvenile calcifying organisms are also more vulnerable to pH changes than adults. Most benthic fauna have a planktonic larval phase when they are especially vulnerable to carbonate undersaturation. For example, young sea urchins were smaller and deformed when grown at a lower pH (Haugan 2006, Shirayama 2004). Also, the success of bivalve larvae is greatly reduced by ocean acidification because they experience high mortality while settling, while undersaturation of carbonates weakens their shells (Royal Society 2005).

Scientists predict that ocean acidification will decrease calcification in shellfish significantly by the end of the century (Gazeau et al. 2007). A recent study found that the calcification rates of the edible mussel and Pacific oyster decrease linearly with increases in carbon dioxide (Gazeau 2007). This study predicted that under by the end of the century, calcification rates would decrease by 10% for oysters and 25% for mussels, probably because mussel shells are largely composed of aragonite. Besides the obvious implications for the commercial shellfish industry, these organisms also play in important role in aquatic ecosystems. They govern nutrient flow, provide habitat for benthic organisms, and are a part of the shoreline food web.

Due to ocean acidification, within our lifetimes coral reefs may erode faster than they can rebuild (Feely 2006). Coral reefs provide vital functions for marine ecosystems, and studies reveal that coral is extremely vulnerable to ocean acidification (Gattuso 1997). Scientists studying ocean acidification predict that coral reefs will decline in density and diversity unless carbon dioxide emissions are stabilized at present levels (Hoegh-Guldberg et al. 2007). Under conservative models of future carbon dioxide emissions, most of the world's coral reefs will erode to rubble by the end of the century (Hoegh-Guldberg et al. 2007). Based on studies of other corals, it is predicted that calcification of cold-water corals will also be reduced by ocean acidification (Lumsden 2007, Turley et al. 2007, Royal Society 2005). Cold water corals may be even more sensitive to reduced carbonate saturation because they already live in conditions less favorable to calcification (Royal Society 2005; Murray 2006). Moreover, because cold water corals depend on calcifying plankton as food, the productivity of coral prey is also compromised by ocean acidification (Lumsden 2007, Morgan 2006).

3. Other Marine Animals Are Adversely Impacted by Ocean Acidification

Even marine animals that do not calcify are threatened by carbon dioxide increases in their habitat. Changes in the ocean's carbon dioxide concentration result in accumulation of carbon dioxide in the tissues and fluids of fish and other marine animals, called hypercapnia, and increased acidity in the body fluids, called acidosis. These impacts can cause a variety of problems for marine animals including difficulty with acid-base regulation, calcification, growth, respiration, energy turnover, and mode of metabolism (Pörtner 2004).

An animal's ability to transport oxygen is reduced by pH changes (Pörtner 2005). Water breathing animals have a limited capacity to compensate for changes in the acidity (Haugan 2006). For example, fish that take up oxygen and respire carbon dioxide through their gills are vulnerable because decreased pH can affect the respiratory gas exchange (Royal Society 2005). Changes in metabolic rate are caused by the changes in pH, carbonates, and carbon dioxide in marine animals (Haugan 2006).

Squid, for example, show a very high sensitivity to pH because of their energy intensive manner of swimming (Royal Society 2005). Because of their energy demand, even under a moderate 0.15 pH change squid have reduced capacity to carry oxygen and higher carbon dioxide pressures are likely to be lethal (Pörtner 2004). Even species more tolerant to pH changes experience decreased metabolism from increased carbon dioxide in the water (Pörtner 2004). For example, as much as 50% mortality was observed in copepods after only six days of exposure to waters with a pH level 0.2 units below the control (Pörtner 2005).

In fish, pH also affects circulation. When fish are exposed to high concentrations of carbon dioxide in seawater cardiac failure causes mortality (Ishimatsu 2004). At lower concentrations sublethal effects can be expected that can seriously compromise the fitness of fish. Juvenile and larval stages of fish were found to be even more vulnerable (Ishimatsu 2004).

An increased concentration of carbon dioxide not only produces pH changes that affect animals, but also the internal accumulation of carbon dioxide in the body of the organism adversely impacts many marine species (Haugan 2006). Marine animals are likely to have difficulty reducing carbon dioxide in their bodies with consequent effects on development and reproduction (Turley 2006). Hypercapnia can cause decreased protein synthesis which results in reduced growth and reproduction (Haugan 2006). This effect has been observed in mollusks, crustaceans, and fish (Haugan 2006). Additionally, studies have found loss of sperm motility for Pacific oysters, decreases in egg production by copepods, decreased hatching of egg sacs for gastropod mollusks, and impacts on reproductive success for silver sea bream and sea urchins (Royal Society 2005).

In sum, ocean acidification can have many adverse effects on marine animals that can reduce their fitness and survival (Royal Society 2005). Many marine animals have low thresholds for long-term carbon dioxide exposure (Pörtner 2005). Studies demonstrate that many marine species are threatened with population declines and changes in species composition due to the decreased fitness of individuals and compromised reproductive success that is occurring or will result from ocean acidification.

4. Ocean Acidification Could Disrupt the Aquatic Food Web

Declining populations of species that are unable to adjust to ocean acidification will cause major changes in interactions among species in marine ecosystems. For example, the shift from coccolithophores to diatoms in the plankton community can cause a restructuring of the ecosystem at all trophic levels (Royal Society 2005). Additionally, a decrease in pteropod abundance can also increase predation of juvenile fish (Royal Society 2005). Changes to the carbonate chemistry and reduced calcification by plankton will change the amount of sinking and settling to deeper waters, which may reduce delivery of food to deeper waters and benthic organisms (Haugan 2006).

Most of the ocean's biological activity happens near the surface waters, and ocean acidification will have substantial effects on organisms and habitats in those areas. Impacts on surface waters will cycle down to affect deep-ocean communities. Changes in acidity occur more quickly near the surface where most marine organisms occur, but deep-ocean species may be more sensitive to pH changes (Caldeira 2003).

Changes in pH also affect the availability of marine nutrients that are essential for marine production (Turley 2006). Changes in nutrients such as phosphorus and nitrogen could cause eutrophication (Turley 2006). The aggregation of these changes may have potentially devastating effects on marine communities.

Due to the specific habitat tolerances of many species, some species may become imperiled from the impacts of high concentrations of carbon dioxide. Additionally, many threatened and endangered species depend on the ocean ecosystem and are extremely vulnerable to changes in marine habitat. Ocean acidification jeopardizes the continued existence of some of these species. For example, ocean acidification may dissolve the shell of the endangered white abalone or inhibit shell formation and growth. Also, there are numerous threatened and endangered species such as blue, humpback, and fin whales, and sea otters that prey on calcifying species. Declining fitness of fish due to acidification could not only impact depleted fish populations, but also already imperiled fish-eating species such as the brown pelican, marbled murrelet, Steller sea lion, Guadalupe fur seal, Kemps Ridley Sea Turtle, and orca. Similarly, impacts to squid, among the most sensitive of marine species to changes in pH, would likely impact squid-eating species such as sperm whales.

As described in this section, the scientific knowledge about ocean acidification has developed significantly within the last few years. Moreover, the process of carbon dioxide absorption in the ocean is well-established and easily predicted through scientific modeling.

IV. Requested Rulemaking

New information on ocean acidification has triggered EPA's duty to revise water quality criteria and information because the "latest scientific knowledge" about ocean acidification derogates the outdated criteria for pH. A revised pH standard would mark the first step toward preventing the harms of ocean acidification and EPA guidance in this field is imperative for states to use their authority under the Clean Water Act to prevent ocean pollution.

Section 304(a) of the Clean Water Act imposes a duty on EPA to periodically revise water quality criteria and information. The Act requires EPA to develop and publish and "from time to time thereafter revise" water quality criteria and information (33 U.S.C. § §1314(a)(1)-(2)). New information that controverts previously held beliefs about water quality and pollutants triggers EPA's duty to review and revise the old criteria. Here, EPA should revise water quality criteria and information to reflect the latest science on ocean acidification.

a. EPA Should Revise National Water Quality Criteria for pH

The Center for Biological Diversity formally requests that EPA initiate a rulemaking pursuant to the Clean Water Act, 33 U.S.C. § 1314(a)(1), to address water quality threats posed by ocean acidification. This Petition for rulemaking specifically requests that the EPA:

(1) Revise national water quality criteria for pH to reflect the latest scientific knowledge about ocean acidification; and
(2) Adopt a criterion for pH stating: "For marine waters, pH should not deviate measurably from naturally occurring pH levels as a result of absorption of anthropogenic carbon dioxide."

Section 304 of the Clean Water Act requires the EPA to publish and revise water quality criteria "from time to time" to "accurately reflect the latest scientific knowledge" (33 U.S.C. § 1314(a)(1)). As presented herein, there is extensive new information concerning seawater pH and the adverse effects of ocean acidification. Pursuant to its duties under the Clean Water Act, EPA must consider this new information and consequently update the national water quality criteria for pH.

The water quality criteria must reflect the latest scientific knowledge related to the effects of pollutants on, *inter alia*, "plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, esthetics, and recreation" and human health (33 U.S.C. § 1314(a)(1)(a)). The criteria must also reflect the latest scientific knowledge "on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes; and...on the effects of pollutants on biological community diversity, productivity, and stability" (33 U.S.C. § 1314(a)(1)(b)-(c)). Each of these factors has changed considerably in light of recent information about ocean acidification and requires updating.

New information shows that the ocean's absorption of carbon dioxide could cause changes in ocean chemistry that harm the ocean ecosystem. There is extensive new research showing that a decrease of 0.2 pH, EPA's current water quality criterion for ocean pH, could pose a risk to the physiology and health of a variety of marine organisms (Calderia 2007). Additionally, models predicting future carbon dioxide emissions can provide reliable estimates of future pH change and new methods of measuring pH and dissolved carbon dioxide can provide useful monitoring tools for water quality.

According to EPA, a "water quality criterion is a level of a pollutant or other measurable substance in water that, when met, will protect aquatic life and/or human health" (*Final Aquatic Life Ambient Water Quality Criteria for Diazinon,* 71 Fed. Reg. 9336 (Feb. 23, 2006)). Water quality criteria developed under section 304(a) must be "based solely on data and scientific judgments...[t]hey do not consider economic impacts or the technological feasibility of meeting the criteria" (*Notice of Availability of Final Aquatic Life Criteria Document for Tributyltin*, 69 Fed. Reg. 342, 343 (Jan. 5, 2004)).

Petitioner requests a new criterion that allows *no measurable deviation* of pH because new scientific information has shown that harm to aquatic life can occur at levels below the current EPA criterion, which allows 0.2 pH change. In light of current science and measuring techniques, a criterion such as the one proposed by Petitioner is reasonable.

Petitioner acknowledges, however, that there are many possible ways that EPA could revise the pH water quality criteria to address ocean acidification. In the alternative to the above criterion, Petitioner requests that EPA promulgate revised pH criteria under section 304(a)(1) that are more stringent than the current criteria and *take into account* the adverse impacts of carbon dioxide on aquatic life. Any revised rule promulgating pH criteria should be subject to input from the scientific community and the public. Public hearings and workshops could provide valuable input for EPA's criteria revisions.

The new criteria should reflect the latest scientific understanding that: (1) marine organisms, especially those that are calcareous, are more sensitive than previously realized to changes of less than 0.2 units in ocean pH; (2) it is possible to make more accurate pH measurements now than in 1976, and thus a narrower range of acceptable values for marine waters is appropriate; (3) human activity is responsible for recent decreases in pH. Petitioner believes that the "no measurable deviation" criteria achieves these goals.

At a minimum, the revised range of allowable pH values should be much narrower than the range in the 1976 guidelines. First, as discussed above, the range must be narrower because it is now well-accepted that devastating impacts occur at pH values that are within the current acceptable range. Second, the scientific methods for measuring pH have vastly improved in the last 30 years allowing more precise evaluation of pH. The spectrophotometric technique, for instance, has a precision of 0.0003—0.0004 pH units (Liu 2006). In addition, it is much more accurate because it is not susceptible to electrode drift throughout the day, as are potentiometric methods that require buffer calibration (*Id.*). The "calibration-free" characteristic of the spectrophotometric method also makes it particularly well-suited to automatic measurements at pH monitoring stations or buoys. With the increased accuracy and precision available for monitoring pH, the acceptable range of values may be narrower because a margin for measurement error is unnecessary.

Moreover, the natural variability in ocean pH does not impede the revision of the pH criteria to reflect knowledge about ocean acidification. The mean pH of open ocean surface waters is 7.9 to 8.3 (Bindoff 2007). Seasonal variability of up to 0.3 units may occur due to temperature and upwelling of deep ocean waters that have higher carbon dioxide concentrations (Royal Society 2005). Coastal waters may exhibit greater variability due to coastal upwelling zones, seasonal photosynthesis, and terrestrial runoff (Chavez 2007). Nonetheless, the variability is smaller than the current pH range in the section 304(a)(1) criteria. Furthermore, observations of weather and water chemistry can be used to reliably predict and correct for seasonal variations (See, e.g. Dore 2003). The EPA already has experience dealing with other pollutants that involve seasonal variability, as exemplified by the Region 10 temperature criteria guidance (www.epa.gov/r10earth/temperature.htm). As a result, it is fully feasible to adopt and enforce water quality standards that comprise a reduced range of acceptable pH and a smaller increment change in pH.

1. Current pH Criteria Do Not Reflect the Latest Scientific Knowledge

The latest scientific knowledge must guide EPA's implementation of water pollution laws. The Clean Water Act states that EPA's water quality criteria must "accurately reflect[] the latest scientific knowledge" (33 U.S.C. § 1314(a)(1)). EPA is required to review its pH criteria using the latest scientific knowledge (*See Our Children's Earth*, 506 F.3d 781 (citing *Bennett v. Spear*, 520 U.S. 154 (1997)).

The EPA must promulgate revised pH guidelines under section 304 because the current pH criteria are woefully out of date and do not reflect the current state of the science.[3] For instance, guidelines for pH were published first in 1976 with the "Red Book", and republished—unchanged—in the "Gold Book" in 1986 (51 Fed. Reg. 43665). The guidelines state that marine waters should have a pH value between 6.5 and 8.5, with no change greater than 0.2 units from normal. Since that time, the state of the science has changed dramatically; scientists now agree that even small reductions in pH may have deleterious effects on the marine ecosystem.

New information about the absorption of carbon dioxide into the ocean has triggered the EPA's duty to revise the pH water quality criteria. The EPA must revise the criteria as new information becomes available. In addition, the EPA has never revised the pH criteria. It has now been over 30 years. This duration surpasses the discretion afforded by the term "from time to time." As the court commented in *Maier v. United States EPA*, the EPA may have a duty to publish revised criteria as new information becomes available where a clause refers to revision from "time to time" (114 F.3d 1032, 1041 (10th Cir. 1997)).

The current pH criteria failed to consider important factors because it was promulgated before much was known about ocean acidification. The discussion section for the current pH criteria, last revised in 1976, states that the normal pH of surface water was 8.0 to 8.2, with deeper waters in the range 7.7 to 7.8. The lowest pH value mentioned was 7.3 in some shallow waters that exhibit diurnal variability from 7.3 to 9.5 due to photosynthesis (51 Fed. Reg. 43665 (1986)). The evaluation considered: effects on toxicity of other pollutants, such as hydrogen cyanide and metals released from sediments; corrosion of plant equipment; effects on water treatment processes; effects on freshwater fish behavior and physical structure; effects on food organisms for fish; effects on marine organisms, effects on industrial and irrigation uses (*Id.*).

New scientific information has rendered existing pH criteria infirm. Very little exploration of effects on marine organisms was included, although the criteria did find that most marine waters exhibited less pH variability than freshwater. The evaluation failed to consider important factors that must now be part of the equation. There was no

[3] Section 304 water quality criteria for other pollutants may be similarly out-of-date, but this petition only requests revision of the pH criteria.

mention of the effects of pH on the ability of calcareous organisms to form shells. In light of current knowledge about ocean acidification, it would be an abdication of EPA's duty to ignore new scientific knowledge and allow this outdated pH standard to persist.

Another change in the scientific knowledge is the source of changes in ocean pH. When EPA promulgated the criteria in 1976, the scientific community was not aware of the devastating effects of small decreases in pH, much less the cause thereof. Now it is well-documented that increased absorption of carbon dioxide is driving the decrease in pH. Additionally, it is equally certain that the source of the carbon dioxide is anthropogenic—the direct result of humans burning fossil fuels. This has been established with a high degree of certainty, for instance, through tracer studies (Gruber 1996). The United States is the largest single source of carbon dioxide, producing 24% of all anthropogenic carbon dioxide emissions. As a result, the United States must play a central role in addressing ocean acidification. The first step is adequate water quality criteria for pH.

This Petition and its supporting documents provide ample scientific basis for revising the pH water quality criteria. New scientific knowledge has rendered the current pH criteria unreasonable because it is too lax to protect water quality from ocean acidification. The current scientific knowledge indicates that small changes in pH have large effects on marine organisms. The marine ecosystem would be destroyed long before ocean pH falls below the current range of acceptable pH values according to the current guidelines. To address the serious shortcomings of the current criteria, the EPA must revise the national water quality criteria.

2. Revised Criteria for pH Will Better Protect Marine Aquatic Life

The Clean Water Act has been construed to provide robust protection of waters of the United States. Under the Clean Water Act, the Administrator of the EPA is obligated to protect water quality for "the protection and propagation of fish, shellfish, and wildlife" (33 U.S.C. 1251(a)(2)). The courts have stated that the provisions of the Clean Water Act are to be construed generously (*United States v. Hamel*, 551 F.2d 107, 112 (6th Cir. 1977)). Furthermore, the courts have indicated that it is the intent of the Clean Water Act to cover all of the waters of the United States, and to regulate such waters "to the fullest extent possible under the Commerce Clause" (*Quivera Mining Co. v. United States EPA*, 765 F.2d 126, 130 (10th Cir. 1985)).

Through the Clean Water Act, Congress gave the EPA the duty to protect and maintain the water quality of our nation. Ocean acidification jeopardizes the health of national waters and aquatic ecosystems. Thus, it is a peril that must be addressed under the Clean Water Act. Addressing ocean acidification begins with accurate, science-based water quality criteria because most other methods of pollution control depend on water quality standards.

The EPA is intimately involved in water quality standards through two mechanisms. First, the EPA must publish water quality criteria under section 304, which are important because they form the basis for state water quality standards (40 C.F.R. § 131.11). Second, the EPA must review and approve or disapprove state water quality standards (33 U.S.C. § 1313(a)-(c)). If the EPA finds that the state's standards are inadequate, the EPA must promulgate water quality standards for the state guided by the national water quality criteria (*Id.*). In turn, a state's water quality standards are the basis for: effluent limitations for point sources (33 U.S.C. § 1312(a)); the identification of impaired water bodies requiring additional protection through TMDLs (33 U.S.C. § 1313(d)); the requirements for section 401 certification (33 U.S.C. § 1341(a)(2)); and National Pollutant Discharge Elimination System (NPDES) permits (33 U.S.C. § 1342(a)).

Water quality criteria established under section 304 serve a regulatory function. EPA's water quality criteria provide guidance to states and tribes in the development and adoption of water quality standards that will protect the designated uses for their waters. *See National Recommended Water Quality Criteria for the Protection of Human Health*, 68 Fed. Reg. 75507, 75509 (Dec. 31, 2003). In fact, EPA encourages states to use EPA's section 304(a) criteria as guidance (*Id.*). States must revise their water quality criteria to reflect changes in the published section 304 guidelines (*See, e.g.*, 63 Fed. Reg. 67548 Part III (1998)). Once adopted, the criteria are a basis for developing regulatory controls on the discharge or release of pollutants (*See, e.g.,* 71 Fed. Reg. at 9336). Additionally, EPA uses the water quality criteria for promulgating federal water quality regulations under section 303(c) of the Clean Water Act (*Id.*).

The current guidelines have not provided adequate guidance to the states as evidenced by the wide array of pH standards that coastal states have adopted. Some states have far less stringent pH ranges: Virginia and Mississippi, for instance, allow pH to fall anywhere within 6.0 to 9.0. A number of states[4] either do not limit the incremental change that is allowed, or allow full 1.0 unit change from normal before considering the standard to be violated. The oceans are under assault from ocean acidification because the EPA has failed to provide adequate guidance to the states regarding the pH values necessary for healthy marine ecosystems. The revision of the section 304(a)(1) criteria for pH will aid in remedying this problem. A revised pH water quality criteria that takes ocean acidification into account will likely result in states adopting more exacting numeric and narrative criteria.

The Clean Water Act can provide the tools to protect ocean water quality from degradation due to decreasing pH if EPA promulgates new water quality criteria. For example, coastal states that are at risk from declining ocean water quality can use their authority under the Clean Water Act to implement pollution controls. Specifically, section 303(d) requires states to identify waters for which existing controls are inadequate to ensure compliance with water quality standards (33 U.S.C. § 1313(d)). A water body failing to meet any numeric criteria, narrative criteria, waterbody uses, or antidegradation requirements shall be included on the 303(d) List (40 C.F.R. § 130.7(b)(3)). Once listed, states must take steps to reduce the pollution causing the impairment by establishing

[4] Oregon, Connecticut, Maryland, Virginia, North Carolina, Florida, Alabama, Mississippi, Louisiana, Texas, Puerto Rico

TMDLs (33 U.S.C. § 1313(d)). TMDLs limit the total amount of a pollutant that can be loaded into a waterbody from all combined sources. Updated water quality standards would aid states in identifying whether their ocean waters are at risk from ocean acidification. This could translate into regulation of carbon dioxide emissions that are causing the pH impairment.

b. EPA Must Publish Information Regarding Maintenance of Healthy pH

Petitioners further request that EPA publish information pursuant to section 304(a)(2). Specifically, the EPA should:

Publish information to provide guidance on ocean acidification, including:

- **the factors necessary to prevent deleterious pH changes in seawater chemistry due to anthropogenic carbon dioxide emissions;**
- **the factors necessary to prevent adverse impacts of ocean acidification on fish, shellfish, and wildlife; and**
- **the recommended methods for measuring pH.**

The Clean Water Act requires that EPA publish and "from time to time thereafter revise" information regarding four factors of water quality: (A) the maintenance of chemical, physical, and biological integrity of all of the nations waters; (B) the protection and propagation of fish, shellfish, and wildlife; (C) measurement and classification of water quality; and (D) which pollutants are suitable for measuring maximum daily loads related to water quality (33 U.S.C. § 1314(a)(2)). States require this information to adequately evaluate the section 304(a)(1) criteria and their applicability to the state's waters. In addition, the information may play a valuable role in the education of state personnel and during management of state water resources.

It is prudent for EPA to publish new information under section 304(a)(2) because of new scientific knowledge. The legislative history of the Act demonstrates that this provision of the Act was intended to provide up-to-date information as needed to protect water quality. The only information published and announced in the Federal Register regarding paragraphs (A)-(C) was a notice in 1973 (38 Fed. Reg. 29836) that the "Water Quality Information" document was available for comment.[5] This single attempt to publish information under section 304(a)(2) was insufficient, as noted when the Clean Water Act of 1977 was adopted by Senate: "The Administrator is required to publish information on the factors needed to assure attainment of that degree of water quality. I

[5] The EPA has published information under subsection (D) stating that all pollutants are suitable for measuring maximal daily loads (43 Fed. Reg. 60662 (1978)). Thus, paragraph (D) is the only portion of this subsection that does not require revision because the determination to include all pollutants is still valid today.

sponsored the amendment [sections 304(a)(4)-(6)] requiring this because of the inadequacies of EPA's earlier efforts under section 304(a)(2) of the 1972 law." (95th Cong. Senate Debates 1977: 39197).

Furthermore, the publication of information in 1973 predates the pH criteria and certainly does not contain updated information that reflects current knowledge of ocean acidification and pH measurement techniques. Thus, the EPA has a non-discretionary duty to publish such information.

Current information about pH certainly does not contain updated information that reflects current knowledge of ocean acidification, and its impacts on: (A) the chemical and biological integrity of marine waters, (B) its affects on the protection and propagation of fish, shellfish, and wildlife, and (C) pH measurement techniques. Thus, the EPA has a non-discretionary duty to publish such information.

When addressing the requirements of paragraph (A), the EPA should publish information on ocean acidification, including an explanation of the effects of carbon dioxide emissions on ocean pH. It should also describe how changes in ocean chemistry caused by anthropogenic carbon dioxide threaten the biological integrity of our oceans. As discussed above, the scientific literature provides extensive evidence that anthropogenic carbon dioxide emissions are the direct cause for the precipitous decline in ocean pH that has occurred since the mid-1700s. Thus, carbon dioxide emissions must be limited to address ocean acidification. States can better apply the necessary controls on carbon dioxide emissions to address decreases in ocean pH if the EPA first provides information under section 304(a)(2)(A).

Approaches to protect marine life from ocean acidification are vital. Likewise, more information should be made available to states, as required by paragraph (B), detailing how important it is to slow the process of ocean acidification to protect fish, shellfish, and wildlife that depend on them. Information should include data on the impacts of ocean acidification on calcification processes and the fitness of marine animals. The purpose of subsection (B) is to disseminate pertinent information that the states need when making priorities and determining what water quality standards are necessary and appropriate. The states must be informed of the extremely detrimental effects of even seemingly minute changes in ocean pH. This is particularly important in the context of ocean acidification because once these changes occur; they cannot be reversed on human time scales (Caldiera 2007).

Updated information on accurate pH measurement methods must be published pursuant to paragraph (C), as well as guidance on effective monitoring for ocean acidification. This is absolutely essential to any water quality standard because the validity and enforceability of the standard depends entirely on the methods of measurement that are employed. Measurement and classification of water quality for pH has not been directly addressed, although 40 C.F.R. § 136.3, which only applies to Clean Water Act sections 401, 402, and 407, outlines acceptable measurement methods for pH. Under Table 1B (40 C.F.R. § 136.3), the list of approved inorganic test procedures, pH may be measured by electronic measurement or automated electrode. This method is not adequate in light of ocean acidification. According to some scientists, the current best method available is spectrophotometric measurement (Liu 2006). Among the benefits of this method is that it is orders of magnitude more precise than potentiometric pH measurements and is virtually "calibration-free" so that problems of electrode drift are non-existent.

In sum, EPA should publish information under section 304(a)(2)(A)-(C) regarding: (A) the factors necessary to prevent deleterious pH changes in seawater chemistry due to anthropogenic carbon dioxide emissions; (B) the factors necessary to prevent adverse impacts of ocean acidification on fish, shellfish, and wildlife; and (C) the recommended methods for measuring pH and monitoring changes over time.

States need information pursuant to section 304(a)(2) on ocean acidification to (1) guide water quality standards; (2) improve monitoring; and (3) regulate pollution causing ocean acidification.

V. Conclusion

Ocean health is declining. In particular, anthropogenic carbon dioxide pollution is causing ocean acidification with drastic consequences for all sea life. Under the Clean Water Act, the EPA is directed to protect all of the nation's waters from pollution and maintain water quality. EPA can squarely address ocean acidification under its Clean Water Act authority.

To adequately address the problem of ocean acidification due to carbon dioxide pollution, the EPA must promulgate new water quality criteria under Clean Water Act section 304(a)(1) to accurately reflect the latest scientific knowledge regarding the dangers of decreased ocean pH and the known causes.

Furthermore, the EPA is requested to publish information pursuant to section 304(a)(2) providing guidance on ocean acidification to provide much needed information to the states and serve as the basis for a comprehensive and uniform approach to ocean acidification.

VI. Severability

If any provision of this petition is found to be invalid or unenforceable, the invalidity or lack of legal obligation shall not affect other provisions of the petition. Thus, the provisions of this petition are severable.

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